1.12 Biology: Homeostasis and Response: Test Pack

AQA 7402 · Calculator allowed · about 45 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Organisms coordinate responses to changes in their internal and external environment using two main communication systems: the nervous system and the endocrine (hormonal) system.

(a) State four structural or functional differences between nervous communication and hormonal (endocrine) communication in the body. **(4)**

(b) Explain why a target cell only responds to a particular hormone, even though that hormone is carried throughout the whole body in the blood. **(2)**

(c) Using body temperature as an example, explain how negative feedback control differs from positive feedback control. **(3)**

(Total for Question 1 is 9 marks)

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2 The nephron is the functional unit of the kidney. Blood entering the kidney is filtered at high pressure in the Bowman's capsule, in a process called ultrafiltration.

(a) Describe how the structures of the glomerulus and Bowman's capsule bring about ultrafiltration. **(5)**

(b) State two substances that would be present in the glomerular filtrate but not (normally) in the urine, and explain why this is the case. **(3)**

(c) Explain why plasma proteins are not normally found in the glomerular filtrate. **(2)**

(Total for Question 2 is 10 marks)

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3 Blood glucose concentration is monitored and controlled by cells within the islets of Langerhans in the pancreas.

(a) Describe how a rise in blood glucose concentration is detected and leads to the release of insulin. **(3)**

(b) Explain how insulin lowers blood glucose concentration once released into the blood, referring to liver and muscle cells. **(5)**

(c) Using the term 'second messenger', explain how insulin binding to a receptor on the outside of a liver cell membrane can bring about changes inside the cell without insulin itself entering the cell. **(3)**

(Total for Question 3 is 11 marks)

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Mark scheme · 1.12 Biology: Homeostasis and Response: Test Pack

Question 1

(a) nervous communication uses electrical impulses carried along neurones, whereas hormonal communication uses chemical messengers (hormones) carried in the blood (oe) **B1**

(a) nervous impulses travel very rapidly (up to around 100 m/s), whereas hormones travel more slowly, limited by the speed of blood flow (oe) **B1**

(a) nervous responses act on a very specific, localised effector (connected directly by a neurone), whereas hormones travel throughout the whole body and can act on any cell with the complementary receptor (oe) **B1**

(a) nervous responses tend to be rapid but short-lived, whereas hormonal responses tend to take longer to begin but can be longer-lasting (oe). Any four creditable differences. **B1**

(a) Answer: Nervous communication is electrical and very fast, acting on a specific, localised effector for a short duration; hormonal communication is chemical, carried in the blood, generally slower to act, but can affect many cells throughout the body for a longer duration.

(b) the hormone can only bind to and affect cells that have a complementary-shaped (specific) receptor for that hormone, on or in the cell **M1**

(b) cells that lack this specific receptor are not affected, because the hormone cannot bind to them (oe) **A1**

(b) Answer: Only cells with a complementary receptor for that specific hormone can bind it and respond; cells without the receptor are unaffected even though the hormone reaches them in the blood.

(c) in negative feedback, a change away from the normal level (e.g. a rise in body temperature above 37°C) triggers a response (e.g. sweating, vasodilation) that reverses/counteracts the change, returning the level back towards normal **B1**

(c) in positive feedback, a change away from the normal level triggers a response that increases/amplifies the original change further, moving the level further away from normal, rather than restoring it **B1**

(c) negative feedback is the basis of most homeostatic mechanisms (maintains a stable set point), whereas positive feedback is comparatively rare and usually drives a process towards a definite endpoint, rather than maintaining long term stability (oe) **B1**

(c) Answer: Negative feedback reverses a deviation from the normal level (e.g. correcting a rise in body temperature back towards 37°C), whereas positive feedback amplifies the original deviation further away from normal.

Question 2

(a) the afferent arteriole (entering the glomerulus) has a larger diameter than the efferent arteriole (leaving it), which creates a high hydrostatic pressure within the glomerular capillaries **B1**

(a) this pressure forces small molecules (water, glucose, amino acids, mineral ions, urea) out of the blood, through fenestrations (pores) in the capillary endothelium **B1**

(a) and through the basement membrane, which acts as a filter, preventing large molecules such as plasma proteins from passing through (they remain in the blood) **B1**

(a) and through filtration slits between the foot-like processes (pedicels) of the podocyte cells forming the wall of the Bowman's capsule **B1**

(a) into the capsule space, forming the glomerular filtrate; blood cells are also too large to be filtered and remain in the blood (any 5 for 5 marks) **B1**

(a) Answer: High hydrostatic pressure, caused by the wider afferent than efferent arteriole, forces water and small solutes out of the glomerular capillaries through the fenestrated endothelium, basement membrane and podocyte filtration slits into the Bowman's capsule, forming the filtrate; proteins and blood cells are too large to pass through.

(b) glucose and/or amino acids named as present in filtrate but not (normally) in urine **B1**

(b) these molecules are small enough to be filtered at the glomerulus, so are present in the glomerular filtrate **M1**

(b) but they are completely (selectively) reabsorbed back into the blood in the proximal convoluted tubule (by active transport/co-transport), so none remains to be excreted in the urine of a healthy person **A1**

(b) Answer: Glucose and amino acids: both are small enough to be filtered into the glomerular filtrate, but are completely reabsorbed by active transport/co-transport in the proximal convoluted tubule, so none normally remains in the urine.

(c) plasma proteins are large molecules with a high relative molecular mass **B1**

(c) the basement membrane acts as a filtration barrier that prevents these large molecules from passing into Bowman's capsule; they remain in the blood, which leaves the glomerulus through the efferent arteriole (oe) **B1**

(c) Answer: Plasma proteins are large molecules that cannot pass through the basement membrane into Bowman's capsule, so they remain in the blood leaving the glomerulus through the efferent arteriole.

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Question 3

(a) β cells in the islets of Langerhans (in the pancreas) detect a rise in blood glucose concentration; glucose diffuses into the β cells and is respired, raising the ATP concentration in the cell **B1**

(a) the raised ATP concentration causes potassium channels in the β cell membrane to close, which depolarises the cell membrane **B1**

(a) depolarisation causes voltage-gated calcium channels to open; Ca^{2+} ions enter the cell, causing insulin-containing vesicles to move to the membrane and release insulin by exocytosis **B1**

(a) Answer: Beta cells detect raised blood glucose, respire the glucose to raise ATP, which closes K^+ channels and depolarises the membrane; this opens Ca^{2+} channels, and Ca^{2+} influx triggers exocytosis of insulin.

(b) insulin binds to specific (glycoprotein) receptors on the cell-surface membrane of liver and muscle cells **B1**

(b) in muscle cells, insulin causes GLUT4 glucose transporters to be moved to and inserted into the cell-surface membrane **B1**

(b) the additional GLUT4 transporters increase facilitated diffusion of glucose into muscle cells, removing glucose from the blood faster **B1**

(b) insulin activates enzymes that convert glucose to glycogen for storage (glycogenesis) in liver and muscle cells **B1**

(b) insulin suppresses glucose production by liver cells, reducing glucose release into the blood; hepatocytes mainly use GLUT2 rather than insulin-triggered GLUT4 insertion **B1**

(b) Answer: Insulin binds to receptors on liver and muscle cells. In muscle, GLUT4 insertion increases glucose uptake by facilitated diffusion. Insulin stimulates glycogenesis in liver and muscle and suppresses hepatic glucose production. Hepatocytes mainly use GLUT2; their response does not depend on GLUT4 insertion. These effects lower blood glucose concentration.

(c) insulin (a large, water-soluble/protein hormone) cannot cross the phospholipid cell-surface membrane, so it binds to a specific receptor protein on the outside of the membrane **M1**

(c) binding of insulin causes a conformational (shape) change in the receptor, which activates a chain/cascade of enzyme-controlled reactions in the cytoplasm, producing or activating a second messenger **M1**

(c) this intracellular second messenger brings about the cell's response (e.g. activation of glycogenesis / increased glucose uptake), without insulin itself needing to enter the cell **A1**

(c) Answer: Insulin binds an external receptor, causing a shape change that triggers an internal second messenger cascade, which brings about the cell's response without insulin crossing the membrane.

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